CLAIMS

1. (currently amended) Apparatus for levitating a magnetic element, ~~the apparatus~~ comprising:

at least ~~two~~ three magnets defining a common plane and arranged to generate a static magnetic field providing a position-dependent potential energy of interaction with a magnetic element located above the plane, the static magnetic field ~~providing~~ defining an elongated equilibrium location wherein the potential energy decreases for displacements of the magnetic element away from the equilibrium location along an unstable axis substantially orthogonal to the longitudinal axis of the elongated equilibrium location and increases for displacements of the magnetic element away from the equilibrium location in any direction ~~perpendicular to~~ along the ~~unstable~~ longitudinal axis;

a position sensor generating a feedback signal indicative of the location of the magnetic element on the unstable axis;

an electromagnet configured to generate a control magnetic field upon the passage of an electrical current through the electromagnet, the control magnetic field having a gradient with respect to displacements along the unstable axis at the equilibrium location; and

a controller connected to receive the feedback signal and to control the electrical current in the electromagnet to prevent the magnetic element from leaving a vicinity of the equilibrium location.

2. (original) An apparatus according to claim 1 wherein the electromagnet comprises at least two coils spaced along an axis parallel to the unstable axis.

3. (original) An apparatus according to claim 2 wherein the at least two coils are rectangular coils having long sides extending transversely to the unstable axis.

4. (withdrawn) An apparatus according to claim 2 wherein the electromagnet comprises four coils spaced along an axis parallel to the unstable axis wherein upon the passage of the electrical current through the four coils each of the four coils has a magnetic polarity opposite to the magnetic polarity of adjacent ones of the four coils.

5. (withdrawn) An apparatus according to claim 2 wherein the electromagnet comprises four coils spaced along an axis parallel to the unstable axis, the four coils comprising first and second rectangular coils located between third and fourth rectangular coils wherein, upon the passage of the electrical current through the first through fourth coils, a component of a magnetic field produced by the first and second coils at the equilibrium located is cancelled by a magnetic field produced by the third and fourth coils.

6. (currently amended) An apparatus according to claim ~~2~~ 3 wherein the coils of the electromagnet are substantially coplanar with the coplanar magnets.

7. (withdrawn) An apparatus according to claim 1 wherein the electromagnet is configured to generate a quadrupole magnetic field at the equilibrium location upon the passage of the electrical current.

8. (currently amended) An apparatus according to claim 1 wherein the at least ~~two~~

three magnets comprise first, second, third and fourth magnets arranged in a diamond pattern ~~with me first and second magnets closer together than the third and fourth magnets~~.

9. (original) An apparatus according to claim 8 wherein the third and fourth magnets are stronger than the first and second magnets.

10. (currently amended) An apparatus according to claim ~~1~~ 8 wherein the ~~at least two~~ four magnets comprise first and second magnets spaced apart from one another by a first distance, D1 in a direction parallel to the unstable axis and third and fourth magnets spaced apart from one another by a second distance, D2, in a direction ~~transverse to the unstable~~ along the longitudinal axis, wherein D1 < D2, each of the first and second magnets is equidistant from ~~an~~ the longitudinal axis ~~of symmetry of the at least two magnets~~ and each of the third and fourth magnets is equidistant from the unstable axis ~~of symmetry~~.

11. (original) An apparatus according to claim 10 wherein each of the first and second magnets is equidistant from each of the third and fourth magnets.

12. (previously presented) An apparatus according to claim 10 wherein each of the first, second, third and fourth magnets has a first magnetic pole facing toward the equilibrium location and a second magnetic pole facing away from the equilibrium location and the first magnetic poles of the first, second, third and fourth magnets are substantially coplanar.

13. (original) An apparatus according to claim 12 wherein the first magnetic poles of the first, second, third and fourth magnets are substantially coplanar adjacent to a plane extending perpendicular to the symmetry axis.

14. (original) An apparatus according to claim 13 wherein the electromagnet comprises at least two coils lying parallel to and adjacent the plane.

15. (currently amended) An apparatus according to claim 1 wherein the at least ~~two~~ three magnets comprise permanent magnets.

16. (currently amended) An apparatus according to claim 1 wherein the at least ~~two~~ three magnets are all permanent magnets.

17. (previously presented) An apparatus according to claim 10 wherein the electromagnet comprises at least two coils spaced along an axis parallel to the unstable axis and the first one of the at least two coils extends around the first magnet and a second one of the at least two coils extends around the second magnet.

18. (original) An apparatus according to claim 17 where the at least two coils of the electromagnet each have width W1 along the axis parallel t the unstable axis equal to an equilibrium height D3, wherein the equilibrium height D3 is a distance between the equilibrium position and a plane passing th rough the at least two coils.

19. First occurrence (Cancelled)

19. (withdrawn) an apparatus according to claim 18 comprising third and fourth coils positioned along the axis parallel to the unstable axis on either side of and adjacent to the first and second coils, the third and fourth coils having the widths W2 at least equal to width W1 of the first and second coils.

20. (withdrawn) An apparatus according to claim 17 wherein the third and fourth permanent magnets are both located outside of any of the at least two coils.

21. (previously presented) An apparatus according to claim 17 wherein the at least two coils comprise rectangular coils.

22. (withdrawn) An apparatus according to claim 17 wherein the at least two coils comprise semi-circular coils.

23. (withdrawn) An apparatus according to claim 17 wherein the at least two cols comprise triangular coils.

24. (withdrawn) An apparatus according to claim 12 wherein the first, second, third and fourth magnets are positioned such that a line passing through the first and second magnetic poles of each of the first, second, third and fourth magnets intersects and forms an acute angle with the axis of symmetry.

25. (previously presented) An apparatus according to claim 8 wherein the first, second, third and fourth permanent magnets are permanent magnets selected from a group consisting of NdFeB, Barium Ferrite, Samarium Cobalt and AlNiCo magnets.

26. (withdrawn) An apparatus according to claim 1 comprising an arrangement of field reinforcing magnets positioned to generate a magnetic field which has substantially no gradient at the equilibrium location and which augments the static magnetic field near the equilibrium position.

27. (withdrawn) An apparatus according to claim 26 wherein the arrangement of field reinforcing magnets comprises at least three magnetic dipoles spaced apart to form a ring.

28. (withdrawn) An apparatus according to claim 27 wherein the at least three magnetic dipoles comprise at least three permanent magnets spaced apart to form the ring.

29. (withdrawn) An apparatus according to claim 27 wherein the arrangement of field reinforcing magnets comprises a secondary electromagnet.

30. (withdrawn) An apparatus according to claim 29 comprising a secondary controller for controlling an electrical current through the secondary electromagnet and a secondary sensor for generating a feedback signal indicative of a distance of the magnetic element from a plane passing through the secondary electromagnet.

31. (withdrawn) An apparatus according to claim 1 comprising a transmitting coil connected to a source of alternating current having a frequency in excess of 10 kHz wherein the magnet element comprises a receiving coil and an electrical device powered by electrical current induced in the receiving coil.

32. (withdrawn) An apparatus according to claim 31 wherein the electrical device comprises a rectifier connected to supply direct current to a motor.

33. (withdrawn) An apparatus according to claim 31 wherein the electrical device comprises a lamp.

34. (withdrawn) An apparatus according to claim 1 comprising a light source oriented to direct a beam of light at a light receptor on the magnetic element wherein the magnetic element comprises an optical system for directing light from the light receptor to one or more visible locations on the magnetic element.

35. (withdrawn) An application according to claim 1 comprising a support moveable between ~~an~~ first position in which the support supports the magnetic element approximately at the equilibrium location, and a second position in which the support is out of the way of the equilibrium location.

36. (withdrawn) An apparatus according to claim 1 comprising a secondary electromagnet disposed to apply a force to the levitated magnetic element.

37. (withdrawn) Apparatus for levitating a magnetic element, the apparatus comprising:

means for generating a static magnetic field providing a position-dependent potential energy of interaction with a magnetic element, the static magnetic field providing an equilibrium location wherein the potential energy decreases for displacements of the magnetic element away from the equilibrium location along an unstable axis and increases for displacements of the magnetic element away from the equilibrium location in any direction perpendicular to the unstable axis;

means for generating a feedback signal indicative of the location of the magnetic element on the unstable axis;

control means for directing the magnetic element to the equilibrium location by providing a quadrupole control magnetic field at the equilibrium location in response to the feedback signal.

38. (withdrawn) A method for levitating a magnetic element at an equilibrium location, the method comprising:

providing a static magnetic field providing a position-dependent potential energy of interaction with a magnetic element, the static magnetic field providing an equilibrium location wherein the potential energy decreases for displacements of the magnetic element away from the equilibrium location along an unstable axis and increases for displacements of the magnetic element away from the equilibrium location in any direction perpendicular to the unstable axis;

generating a feedback signal indicative of the location of the magnetic element on the unstable axis;

forcing the magnetic element toward this equilibrium location by providing a quadrupole control magnetic field at the equilibrium location in response to the feedback signal.

39. (currently amended) Apparatus for levitating a magnetic element, the apparatus comprising:

at least ~~two~~ three magnets defining a plane and arranged to generate a static magnetic field providing a position-dependent potential energy of interaction with a magnetic element located above the plane, the static magnetic field providing an equilibrium location wherein the potential energy decreases for displacements of the magnetic element away from the equilibrium location along an unstable axis and increases for displacements of the magnetic element away from the equilibrium location in any direction perpendicular to the unstable axis, the at least two magnets comprising first and second magnets spaced apart from one another by a first distance, D1, in a direction parallel to the unstable axis and third and fourth magnets spaced apart from one another by a second distance, D2, in a direction perpendicular to the unstable axis, wherein D1 < D2 and each of the first and second magnets and each of the third and fourth magnets is equidistant from the axis of symmetry;

a position sensor generating a feedback signal indicative of the location of the magnetic element on the unstable axis; and

a controller connected to receive the feedback signal and to control a means for applying a controllable force to the magnetic element to direct the magnetic element to the equilibrium location.

40. (withdrawn) Apparatus for levitating a magnetic element, the apparatus comprising:

at least two magnets arranged to generate a static magnetic field providing a position-dependent potential energy of interaction with a magnetic element, the static magnetic field providing an equilibrium location wherein the potential energy decreases for displacements of the magnetic element away from the equilibrium location along an unstable axis and increases for displacements of the magnetic element away from the equilibrium location in any direction perpendicular to the unstable axis, the at least two magnets comprising at least two magnetic dipoles spaced apart around a ring, the at least two magnetic dipoles providing a magnetic field component having substantially no gradient at the equilibrium location;

a position sensor generating a feedback signal indicative of the location of the magnetic element on the unstable axis; and

a controller connected to receive the feedback signal and to control a means for applying a controllable force to the magnetic element to direct the magnetic element to the equilibrium location.

41. (Cancelled)

42. (Cancelled)

43. (new) The apparatus of claim 39 wherein said magnets are smaller in size than the shortest distance between said magnets.

44. (new) The apparatus of claim 39 wherein said means for applying a controllable force is located in the same plane as the at least three co-planar static field magnets.

45. (new) Apparatus for levitating a magnetic element comprising:

at least one magnet shaped so as to generate a static magnetic field defining an oblong potential energy equilibrium location having a dependent position interaction with the magnetic element located above said at least one magnet, wherein the potential energy increases for displacements of the magnetic element away from the equilibrium location along the major axis of the oblong equilibrium location and decreases for displacements of the magnetic element away from the equilibrium location in any direction along the minor axis of the oblong equilibrium location;

a position sensor generating a feedback signal indicative of a location of a magnetic element on the minor axis;

an electromagnet configured to generate a controlled magnetic field upon the passage of an electric current through the electromagnet, the controlled magnetic field having a gradient with respect to displacements along the minor axis of the equilibrium location; and

a controller connected to receive the feedback signal from the position sensor and to control the electrical current in the electromagnet to prevent the magnetic element from leaving the vicinity of the equilibrium location.

46. (new) The apparatus of Claim 45 wherein said at least one magnet has an oblong shape.

47. (new) The apparatus of Claim 45 wherein said at least one magnet comprises one ring magnet and one or more additional magnets the composite magnetic field of which creates an equilibrium location having an elongated shape.